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NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
ENGINEERING TECHNICAL SUPPORT CENTER
CINCINNATI, OHIO 45268

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MEMORANDUM

SUBJECT: Observations on EPA Region 2 documents received from a response to a 104e request, Rahway Arch site, Carteret, New Jersey

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TO: Pat Evangelista
U.S. EPA Region 2

This memorandum was prepared in response to a March 30, 2015 e-mail request from EPA Region 2. The e-mail requested that the Engineering Technical Support Center (ETSC) provide observations on documents submitted to the Region as a response to a 104e request. The 104e request was for additional documentation on the proposed remedy to be used at the Rahway Arch Properties site. As requested by the Region, the focus of this memorandum is to provide our observations on the functionality of the berms and the presented alternatives. Observations in this memorandum are intended to provide a summary of points for consideration from the documents reviewed. The ETSC did not evaluate the data collection or analysis protocols followed by the site owner (owner) or their contractors, therefore the data and documentation received were assumed to comply with Regional and owner data quality criteria.

We reviewed the documents received pertaining to the Rahway Arch Properties site located in Carteret, New Jersey. Given the volume of documents provided, we focused on those documents with appropriate technical information to address the Regional support request we received. Documents reviewed in most detail included:

1. Rahway Arch Site, Carteret, New Jersey – Response to Request for Information (February 2015)
2. Remedial Action Workplan for the Rahway Arch Properties Site (EastStar, July 2013)
3. Rahway Arch Site Remediation – Detailed Alternatives Analysis prepared by EastStar Environmental Group (EastStar, January 2013)
4. Remedial Investigation Report, Rahway Arch Properties Site, Carteret, New Jersey (EastStar, November 2012)
5. Preliminary Report Of Test Borings And Dike Evaluation at the Warner's Plant Impounds (Disko, 1982)
6. Final Geotechnical Engineering Report (Baker, 2012)
7. Remedial Action Plan Addendum, Carteret Impoundments, Borough of Carteret, New Jersey (Blasland, Bouck & Lee, 1995)

These documents provide an understanding of site conditions, the basis on which the proposed remedy was selected, and the remedy design. Over thirty additional documents of various types were provided to us, but were only briefly reviewed or considered to help understand and address concerns identified based on review of the principal documents listed above. It should

be noted that additional site-specific information may be available, but may not have been provided under the 104e request.

Having completed our review of the documents available for this site, a prime observation is that any selected remedy for this site should be substantiated by a validated engineering design arrived at by an independent, third-party engineering firm or individual. Additional data would also be needed to quantitatively determine whether the proposed cap design would be structurally sound; however, documentation provided by the property owner note signs of berm failure already under current conditions without a cap. Additional considerations for remedy selection include potential conflicts of interest that can arise if the same contractor designs the remedy as well as implements it.

Understanding of the Problem

The Rahway Arch site is 126 acres in area. Six impoundments (sludge containment units) encompass about 85 acres of the site. These impoundments were constructed as early as the 1930s and were used to contain sludge material. Most of the areas around these impoundments consist of wetlands. The wetlands are located adjacent to the Rahway River, which partially surrounds the site on three sides. Historically, periodic flooding of the river and wetland areas has inundated portions of the site. American Cyanamid owned and operated a chemical processing facility at this site that manufactured a variety of chemicals. The six impoundments were used to contain a slurry of waste consisting of an alkaline sludge from a yellow prussiate of soda (YPS) manufacturing process and an acidic sludge from an aluminum sulfate (alum) manufacturing process, which were placed into the impoundments until 1970 and 1974, respectively. It is estimated that the impoundments contain 2,000,000 tons of this waste sludge. The thickness of the sludge ranges from 5 to 20 feet. The sludge is known to contain cyanide, heavy metals and PAHs. Concentrations of metals and cyanide in groundwater exceed applicable standards and concentrations of several metals in groundwater exhibited a significant increase between 1999 and 2012. The Preliminary Assessment at the Rahway Arch Properties Site (EastStar, August 2012) indicates that the sludge is thixotropic, has low shear strength, and little weight-bearing capacity. It was noted that the sludge could not bear sufficient weight to allow for the use of lightly loaded construction equipment. Contaminated sludge was placed directly on the ground on a naturally occurring, organic “meadow mat”. Berms were constructed using uncharacterized soil materials to contain the sludge in impoundments. Once at capacity, the impoundments were covered with uncharacterized fill material. Previous investigations have demonstrated the cover/fill material contains petroleum hydrocarbons, with elevated levels of polycyclic aromatic hydrocarbons (PAHs). This material has been spread across the top of the impoundments and berms, and vegetation has been allowed to grow. However, at this time, the cover material has eroded in some areas, leaving large areas of exposed sludge.

A number of investigations have been performed to characterize the site and assess potential remedial alternatives. Recently, in 2012, a geotechnical evaluation was performed to evaluate the potential for capping the material. A Remedial Alternative Analysis (RAA) was performed in 2013, which identified capping using reclaimed/modified soil as the most suitable remedy for the site. A design for the capping system was developed in 2013 and approval to construct and operate an on-site recycling center for contaminated soil was issued by New Jersey (NJ) to Soil Safe on June 2, 2014.

Remedial Alternative Analysis

The Rahway Arch Site Remediation – Detailed Alternatives Analysis (or RAA) conducted by EastStar in 2013 was reviewed to understand the rationale for selecting the option of capping

the impoundments with engineered fill soil manufactured on-site at a temporary, dedicated Class B recycling facility. Although the RAA presented seven alternatives, they can be broken into the four principal remedy types:

1) No Action (Alternative 1)
2) Excavation (Alternative 2)
3) In Situ Stabilization (Alternative 3)
4) Capping, which includes using:
    - Alternative fill (Alternatives 4)
    - Alternative fill and a geomembrane liner (Alternative 5)
    - Processed dredged material (Alternative 6)
    - Processed Class B recyclable soil (Alternative 7)

Unfortunately, the RAA did not provide substantive data or scientific basis to support the site owner selecting Alternative 7 or to preclude other alternatives from further consideration. However, we agree that excavation (Alternative 2) may result in short-term environmental impacts.

Alternative 3 discusses the use of stabilized sludge/fill materials with top soil placed above it. Depending on the binders (e.g. cement) and other materials used, the resulting stabilized sludge/fill materials could be designed to have a low permeability that would not readily transmit precipitation into the impoundments. Permeability rates (also called hydraulic conductivities) stated in an EPA Technology Performance Review, "Selecting and Using Solidification/Stabilization Treatment for Site Remediation," indicate values less than $1x10^{-6}$ cm s^{-1} are preferred (EPA, November 2009). It is notable that instead of designing a stabilized sludge/fill material cover in Alternative 3, it may be beneficial to investigate and possibly implement options to stabilize/solidify the sludge in the impoundments directly.

There are many similarities between Alternatives 4, 5, 6, and 7 which are all variants of capping. If designed properly, any of the proposed methods could offer similar benefits and limitations. It is unclear why the effectiveness of each of these alternatives varies so widely (see Table 1 of the RAA). For instance (not intended to comprehensively cover all issues):

- The RAA considers Alternative 7 to be "very effective" at preventing precipitation from contacting the contaminated materials; however, Alternative 4 is considered "marginally effective" in this regard. The document states that for Alternative 4 "The fill will likely be more permeable than the underlying alum-YPS sludge, resulting in water being trapped inside the impoundments." However, the fill material in question is not specified. If designed properly, one would expect the material to have a low permeability. For instance, fill material with high clay content could be considered, or if necessary, an additive such as cement (as proposed as part of Alternative 7) could be blended into the cap material to reduce permeability and prevent infiltration of precipitation.
- Alternative 7 is stated to be "very effective" to promote storm water runoff, but Alternative 5, consisting of using alternative fill with a geomembrane cap, is only considered to be "effective". It is unclear how a properly designed geomembrane would not be equally as effective, if not more effective, at promoting runoff as a modified soil on top of the fill material.
- Justifications for not selecting Alternative 6 include characteristics similar to Alternative 7. Specifically, "disadvantages with the use of processed dredge material (PDM) [Alternative 6] are the reliability of the supply, the lack of homogeneity among the various PDM sources and the need to obtain a site specific Acceptable Use Determination (AUD) from each PDM generator and that these uncertainties will likely extend the time required to complete the remediation and make it questionable if a sufficient volume of PDM can be obtained to

complete the site remediation. Variation in the material characteristics will also require additional engineering during the remediation to ensure that the cap is stable and is consistent enough to meet the remediation goals." The Remedial Action Work Plan (RAWP) specifies that (contaminated) soil for Alternative 7 will be obtained from different sources and blended; hence these same "uncertainties" are applicable to Alternative 7, but were not addressed in the RAA.

- It is unclear how costs were estimated for the remedial alternatives evaluated. Although we agree that excavation or stabilization would be costly, there is limited documentation regarding how costs were estimated. In particular, it is difficult to readily understand how Alternative 4, which uses alternative fill without screening or processing, would be more than $8M more expensive than Alternative 7. The methods by which these costs were estimated should be provided to the EPA Region for consideration for future recommendations or actions.

One observation to address these issues is that a more comprehensive feasibility study be performed. Statements such as "fill will likely be more permeable than the underlying alum-YPS sludge" and "Older PDM, not processed on site is likely to be more permeable than the underlying alum-YPS sludge" should be substantiated. It would be helpful if due diligence were performed to identify specific sources of materials, and various treatability tests performed to better understand the potential efficacy of each proposed remedy. In addition, we have identified a number of observed data gaps (below) that would help inform any future feasibility evaluations. Furthermore, it would be useful to have "proof-of-concept" proposals from vendors detailing their approach to the remedial alternatives from the RAA and the materials that they will use, which would be evaluated on the basis of cost, effectiveness, and implementability to avoid potential bias to a particular vendor/process.

Observed Data Gaps

Based on our review of the documents provided, there are a number of observed data gaps that could impact any remedial action undertaken at the site. Although the site owner provides a list of what the desired outcomes of the remedial activities are in their RAWP (EastStar, July 2013, pg. 32), specific Remedial Action Objectives (RAOs) have not been provided. RAOs are more specific than the desired outcomes stated by EastStar. An example of an RAO would be, "decrease or eliminate the transfer of metals and cyanide from the 6 impoundments to the groundwater beneath the site, and the Rahway River." In the current scenario, it is challenging to perform an evaluation of how effective any remedy would be without stated RAOs. Based on our review, potential data gaps include (but are not limited to) the following:

- *There are insufficient data to evaluate, and assure with any degree of certainty, the structural stability of the berms. However, documentation from the property owner identified stability issues.* As noted in the Preliminary Report of Test Borings (Disko, 1982), discovery of sludge under one or more of the berms suggest that the sludge extends beyond the berms. This information is also reiterated in Table 5.1 in the RAWP (EastStar, July 2013), "However, a review of historical boring logs in the vicinity of the berms identified a layer of sludge beneath the berms in some locations. In addition, historical reports indicate that in some areas, sludge likely extends beyond the present location of the berms resulting from several incidents of embankment failure." Additionally, in this same table it is stated that, "The structural stability of the berms is questionable. Previous reports have documented past instances of failures." Borings also indicate that in some areas there is either no berm material present, or berms may have been placed directly on top of sludge. Hence, it would be useful to ensure that the extent of the sludge is fully delineated and any proposed remedy addresses its entire extent.

- *The nature and extent of the contamination is not well understood.* There are only eight relatively shallow (< 60 ft) 2-well clusters installed around the 85 acre area. There are no wells located in large areas toward the east and northeast of the site. In addition, all eight well clusters are located immediately outside of the bermed areas. Concentrations of contaminants of concern (COC) that exceed applicable regulatory criteria have been measured in samples collected from those wells. Furthermore, substantial increases in the concentration of metals have been noted between the 1999 and 2011 sampling events, presumably due to rainwater infiltrating the site, and percolating down to groundwater. Due to the limited number of monitoring wells, it is difficult to assert with any measureable degree of certainty that the extent and concentrations of COC are well understood and characterized. Given this limited information, it is plausible that COC including metals and cyanide could be more widespread outside of the bermed impoundment areas than currently understood.
- *Concentrations of COC in sludge pore water are not known.* Concentrations may be orders of magnitude greater than what is measured in groundwater or in surface water, both of which exhibit exceedances of applicable groundwater standards.
- *Limited information is available regarding chemical makeup and long-term stability of the sludge.* Because a number of the proposed remedies require the sludge to remain in place, it is necessary to understand its potential to attenuate, become unstable, and continue to release various COC. Should the material become unstable, portions of any applied cap could sink and crack. The organic mat underlying the impoundments could be a source of carbon for biodegradation to occur, producing a substantial volume of carbon dioxide and methane. Carbon dioxide could impact the stability of the sludge, which to a large extent, is comprised of calcium carbonate. Methane buildup beneath an impermeable/low permeability cap could result in a hazardous condition. In addition, if not properly vented, a sufficient volume of these gases could compromise the integrity of the cap.
- *There is a lack of concurrent groundwater and surface water chemical concentration and water level data.* Results of the 1995 supplemental remedial investigation by Blasland, Bouck & Lee noted the Rahway River elevation adjacent to the site is tidally influenced and varies roughly 5 ft during an average tidal cycle. Hydrographs from shoreline monitoring wells show that groundwater levels are affected by the change in river level. It would be useful to have continuous data collected from a stilling well in the river and several inland shallow and bedrock groundwater wells on site to further evaluate the tidal and river stage impacts on site groundwater, especially during intense precipitation or storm events. This information would be useful to determine whether river water intrusion would flush the impoundments (push water up through the impoundments), and how far inland from the river this might occur. In addition, it would be useful to evaluate concurrent chemical concentrations in shoreline and adjacent offshore sediment/surface water to identify any chemicals or materials that may be escaping the impoundments through either runoff or dissolution into groundwater.
- *There is no groundwater elevation information within the areal extent of the impoundment areas.* A better understanding of horizontal and vertical groundwater flow within the impoundments would be beneficial before selecting and applying any remedy. Currently, all monitoring wells are located outside the extent of the impoundments. The RI report references a 1987 document that indicates signs of groundwater mounding underneath the site. Since the groundwater is denser than the water mounded in the impoundments, downward infiltration of the water in the impoundments is minimized. If the cap further decreases the amount of water that infiltrates downward, there is the potential that the mounded water in the impoundments will saturate the impoundments and berms. The potential for saturation, and the resulting impact on the stability of the berms and proposed cap would need to be considered.

Cap Design Observations

We have identified a number of potential issues regarding the proposed remedy based on our review of the provided site specific documents. This review had a limited scope, and does not thoroughly critique the many geotechnical issues associated with placement of the cap material, stability of the berms, and consolidation of the underlying sludge as the cap material is placed. To accomplish a thorough critique of the material provided by the site owner, an independent, third-party engineering firm or individual should be engaged by the parties that either have interest in, or may be affected by, the remedy selected for this site. Based on our review, potential design issues include, but are not limited to the following:

- *It is not clearly stated how the berms will be reinforced.* The RAWP indicates that the berms around the impoundments do not have center cores to prevent infiltration of water through the berms. Essentially, groundwater and surface water can move freely through them. This permeation can lead to instability of the berms, and undermines the stability of the proposed cap in Alternative 7. To prevent potential flow through the berms and to reinforce them, it would be necessary to *reduce the permeability of the berms*. As an observation, it would be useful if a remedial alternative that is known to decrease the permeability of the berms (such as slurry injections into the berms) was investigated. One last observation regarding berm stability, if a berm were to fail after application of the proposed cap in Alternative 7, some portion of the unconsolidated sludge would spill out from the impoundment or impoundments into adjacent areas. Given the stated history of dead load berm failure in Table 5.1 of the RAWP (EastStar, July 2013), berm failure could occur due to the additional weight of the proposed cap. If berm failure were to occur, COC released into the adjacent areas would cause increased environmental risk (due to cyanide and metals in the sludge) potentially requiring a re-assessment of the human health and environmental risks associated with this site.
- *The proposed cap in Alternative 7 does not address the permeation of sludge and water from the impoundments under and through the berms*. As mentioned in the data gap section, sludge was found underneath and/or outside the berms. Any remedy must address sludge found to be present in these additional areas. It is mentioned in the RAWP that a proposed, lower permeability mixed-soil cap material would be placed on the outward facing area and top of the berms, as well as on top of the impoundments. This design does not appear to be well formulated. In the best case, it may (although not proven) protect against some weathering and erosion of the external faces of the berms.
- *The RAWP shows that there is an overall groundwater flow direction from upgradient of the site to the north/northeast, where it discharges to the Rahway River*. The groundwater flux from upgradient of the site is likely to continue to flush water from the impoundments into the river during high tide conditions or intense precipitation events and storms. Only remedies that either remove the source of contamination (sludge) or make it impermeable mitigate migration of COC, including metals and cyanide from the impoundments to the Rahway river.
- *Because pore water will be expressed during the application of a cap, including the possibility of pore water being expressed outside of the impoundments, concentrations of contaminants from the sludge should be known. If necessary, appropriate containment/treatment options should also be designed.*
- *The soil immediately beneath the material is a permeable organic mat.* The sludge was placed directly on this natural soil surface. Given that flooding of the site is known to occur during rain events and storms, it is presumed that groundwater/surface water will enter the bermed areas from beneath any applied cap during these events, which will impact chemical composition, leachability, and stability of the sludge over time. The Remedial Investigation Report (EastStar, November 2012) documented elevated levels of a number of metals and cyanide present in the organic mat layer as well as the underlying clay layer that exceed New Jersey Non-residential Direct Contact Remediation Standards and Impact to

Groundwater Screening Levels. This evidence appears to indicate a transport of COC from the sludge through the organic mat into groundwater. As an observation, it would be useful if remedial alternatives that decreased the permeability of the sludge and organic mat below the impoundments (such as solidification or stabilization) were investigated.

- *A detailed remedy construction monitoring plan should be developed and approved prior to remedy implementation*. The monitoring plan should specify all monitoring requirements during remedy construction/implementation as well as include a comprehensive long-term monitoring program for the site.

Thank you for the opportunity to review and provide observations on the subject data and reports. The scientific observations provided here are based only on documents provided by the Rahway Site Owner, through EPA Region 2. It would be advisable to consider this memorandum in conjunction with multiple lines of evidence including history, experiences of site managers, and other pertinent information available to EPA Regional staff for their deliberations and decisions regarding this site. Please feel free to contact me with any questions or comments.

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